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Geographic and population-level disparities in colorectal cancer testing: A multilevel analysis of Medicaid and commercial claims data

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Abstract

Morbidity and mortality from colorectal cancer (CRC) can be attenuated through guideline concordant screening and intervention. This study used Medicaid and commercial claims data to examine individual and geographic factors associated with CRC testing rates in one state (Oregon). A total of 64,711 beneficiaries (4516 Medicaid; 60,195 Commercial) became newly age-eligible for CRC screening and met inclusion criteria (e.g., continuously enrolled, no prior

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history) during the study period (January 2010–December 2013). We estimated multilevel models to examine predictors for CRC testing, including individual (e.g., gender, insurance, rurality, access to care, distance to endoscopy facility) and geographic factors at the county level (e.g., poverty, uninsurance). Despite insurance coverage, only two out of five (42%) beneficiaries had evidence of CRC testing during the four year study window. CRC testing varied from 22.4% to 46.8% across Oregon's 36 counties; counties with higher levels of socioeconomic deprivation had lower levels of testing. After controlling for age, beneficiaries had greater odds of receiving CRC testing if they were female (OR 1.04, 95% CI 1.01–1.08), commercially insured, or urban residents (OR 1.14, 95% CI 1.07–1.21). Accessing primary care (OR 2.47, 95% CI 2.37–2.57), but not distance to endoscopy (OR 0.98, 95% CI 0.92–1.03) was associated with testing. CRC testing in newly age-eligible Medicaid and commercial members remains markedly low. Disparities exist by gender, geographic residence, insurance coverage, and access to primary care. Work remains to increase CRC testing to acceptable levels, and to select and implement interventions targeting the counties and populations in greatest need.

Keywords

Cancer screening; Colorectal cancer; Health disparity; Multilevel analysis; Geographic information systems

1. Introduction

Colorectal cancer (CRC) is the third most diagnosed cancer in the United States (US) and a leading cause of cancer deaths (American Cancer Society, 2014, 2017). National studies describe profound variation in CRC death rates by geographic region and population characteristics (Siegel et al., 2015; Naishadham et al., 2011; Perdue et al., 2014). A recent publication by Siegel and colleagues identified several “hot spots” in the US where CRC death rates were up to 40% higher than national averages (Siegel et al., 2015). Fortunately, the majority of CRC deaths are preventable if individuals engage in healthy behaviors and follow screening guidelines (Tomeo et al., 1999; Johnson et al., 2013).

Screening can lower CRC incidence and mortality by 30–60% (Whitlock et al., 2008). The US Preventive Services Task Force (USPSTF) endorses multiple modalities for CRC screening in average risk age-eligible adult populations, including endoscopic and less invasive fecal testing options (Whitlock et al., 2008). Despite wide-spread efforts, national rates of CRC screening (58%) (Steinwachs et al., 2010; Sabatino et al., 2015) remain well below targets set by the National CRC Roundtable (80% by 2018) (National, Colorectal Cancer Roundtable) and Healthy People 2020 (70.5%) (US, Department of Health and Human Services). Screening rates for CRC are also considerably lower than screening rates for breast and cervical cancers (72% and 81% respectively) (Sabatino et al., 2015).

Individual-, community-, and health care system-level factors influence CRC screening in myriad, dynamic and interrelated ways (Wheeler et al., 2014; Klabunde et al., 2005; Clarke et al., 2016). National data consistently show lower rates of screening in rural areas, and among adults with less education, low income, or no health insurance (Wheeler et al., 2014; Cole et al., 2012; Morbidity, and Mortality Weekly Report (MMWR), 2013; Ojinnaka et al.

2015; Anderson et al., 2013; Holden et al., 2010). While patient preferences influence CRC testing (Lian et al., 2008; Mobley et al., 2010; Pruitt et al., 2009; Schootman et al., 2006; Calo et al., 2015; Pignone et al., 1999; Jones et al., 2010), contextual factors such as provider preferences, clinical workflows or regional characteristics, also play an important role in determining if screening occurs and which screening modalities are used in practice (Pignone et al., 1999; Wolf et al., 2006; Marshall et al., 2007; Mansfield et al., 2016; Martens et al., 2015; Jandorf et al., 2010; Wilkins et al., 2012; Hughes et al., 2015; Benarroch-Gampel et al., 2012). For example, an individual's insurance coverage may influence where they seek care and thus the screening services they are offered. Consideration of these multilevel factors is crucial to understanding geographic variation in CRC screening and informing prevention planning (Subramanian et al., 2009).

Exploring the impact of multilevel factors at the county level can inform regional policies and practices associated with resource allocation, support the selection and targeting of interventions to areas or populations with the greatest need, and reduce observed disparities in CRC deaths by improving screening rates and early intervention (Hassmiller Lich et al., 2017). Therefore, we undertook this study to explore regional variation in CRC testing within one western state (Oregon) and to identify individual (e.g., insurer, use of primary care, race/ethnicity) and community (e.g., education, poverty, provider density) factors associated with observed testing rates. Our research used claims and public data to address an important gap in multilevel cancer prevention and control research by describing a method that provides regional health system leaders and policy makers with actionable information that can be used to select and target interventions to the populations and counties with the greatest needs.

2. Methods

2.1. Overview

We sought to understand differences in relative rates of CRC testing across Oregon's Medicaid and commercially insured populations and identify regional areas and populations with greatest need. We focused on individuals turning 50 years old, the age at which the USPSTF recommends initiating routine CRC screening (Whitlock et al., 2008). We used member-level claims and enrollment data and linked them to regional measures of socioeconomic status from the Area Health Resources Files (AHRF) to examine multilevel determinants of CRC testing. Member-level covariates included gender, race, residential rurality, years of data observed, distance to the nearest ZIP code with an endoscopy facility, and history of accessing primary care. We estimated multilevel models with county-level random effects and created county-specific maps depicting differences in visits to primary care and differences in multivariate-adjusted predicted probabilities of CRC testing across Oregon counties.

2.2. Data

2.2.1. Medicaid and commercial claims—We acquired claims and enrollment data from 2010 to 2013 for Oregon residents insured by Medicaid or commercial plans from Oregon's Health Services Division and All Payer All Claims Database (Oregon, Health

Authority). Claims data include all healthcare encounters that generate a billing claim for enrolled members over specific time periods. Claims data have been used to understand cancer screening patterns in diverse insured populations (Wheeler et al., 2014; Ko et al., 2002; Ko et al., 2005; Koroukian et al., 2005; O'Malley et al., 2005; Schenck et al., 2009; Gupta et al., 2013a; Schenck et al., 2007). The National Institutes of Health (NIH) recently cited a need for more population data sources for measurement of CRC testing, particularly for the medically underserved (Steinwachs et al., 2010; Gupta et al., 2013a). In contrast to patient self-reported cancer screening practices, which may be unreliable or inaccurate due to recall bias and social desirability bias, claims data can provide an objective assessment of cancer screening behaviors in a specific population (Schenck et al., 2007; Dodou and de Winter, 2015; Bradbury et al., 2005).

2.2.2. Area Health Resource File (AHRF) data—Geographic and health care service provider data from the AHRF were explored at the county level and linked to member data using county of residence. The AHRF is a collection of data from >50 sources, including the American Medical Association, the US Census Bureau, and the Centers for Medicare and Medicaid and includes information on income, employment, and education (US, Department of Health and Human Services). This approach has been used in prior studies of CRC screening (Wheeler et al., 2014; Koroukian et al., 2005; Hayanga et al., 2010; Koroukian et al., 2006).

2.3. Population and inclusion/exclusion criteria

We identified men and women who turned 50 years of age during 2010–2013, were insured by Medicaid or commercial insurance, and had a valid ZIP code. Because guidelines differ on frequency of CRC testing by modality - colonoscopy every 10 years, annual testing using Fecal Occult Blood Tests (FOBT) or Fecal Immunochemical Tests (FIT), or flexible sigmoidoscopy every 5 years with FIT/FOBT every 3 years - we focused our analysis on identifying incident CRC testing within a cohort of individuals who were newly age-eligible for CRC screening (Whitlock et al., 2008).

To ensure a complete claims picture of services received, we included only beneficiaries who were continuously enrolled (defined as at least 11 of 12 months annually) and alive for the entire study period. This enabled the systematic examination of CRC testing at the individual level during multiple years. Because of the importance of county level factors in our analyses, we excluded a small minority of beneficiaries who lived in more than two counties during the study period (<0.09%). Members residing in two counties were assigned to the county in which they resided the longest during the study period. For Medicaid members, we excluded individuals who were dually eligible for Medicare (because we lacked the ability to access Medicare Advantage claims). To better ensure that our measures reflected CRC testing rather than surveillance procedures, we excluded beneficiaries with a history of CRC or total colectomy based on available claims. We also excluded individuals with end stage renal disease (ESRD), a terminal illness which would preclude physicians from recommending cancer screening and a criteria applied in prior cancer screening studies (Wheeler et al., 2014; Wheeler et al., 2012). As summarized in Fig. 1, these exclusion criteria rendered a total of 64,711 individuals in our sample (4516 Medicaid and 60,195 Commercial beneficiaries).

2.4. Dependent variable

Our primary outcome was a binary indicator of whether the beneficiary received any type of CRC testing procedure during the four year study period, including colonoscopy, FOBT/HT, or flexible sigmoidoscopy. These modalities were measured as separate procedures, each potentially indicating that a screening test was performed, consistent with USPSTF guidelines. Services were identified by the International Classification of Diseases, 9th Edition, Clinical Modification (ICD-9-CM), Current Procedural Terminology (CPT), or Healthcare Common Procedure Coding System (HCPCS) codes and are summarized in Appendix 1.

For fecal testing, we examined non-specific codes (i.e., 82271, 82272,82273) in sensitivity analyses to explore how often they occurred concurrently with a CRC screening test-specific code and discovered that usage of non-specific codes decreased in a stepped fashion from 24% in 2010 to <6% in 2013. Because this decrement may be related to coding improvement and not differences in testing behaviors, we kept non-specific procedures in the analysis. With regard to endoscopy procedures, we applied best practices to include procedures performed for screening and diagnostic intent (Wheeler et al., 2014; Schenck et al., 2007). Although insurance claims data accurately assess whether a patient has undergone colonoscopy testing, distinguishing procedural intent (screening versus symptomatic) is not reliable from claims data, nor is it any more reliable from self-report or medical records data (Schenck et al., 2007). Due to challenges in distinguishing colonoscopy intent we included both screening and diagnostic billing codes for colonoscopy in our analysis (see Appendix 1).

2.5. Independent variables

Independent variables included individual-level characteristics, such as gender (Male, Female), race/ethnicity (White non-Hispanic, African-American non-Hispanic, Hispanic, Other), insurance type (Medicaid, Commercial), observed years after turning 50, geographic residence (Urban, Rural, Frontier), use of primary care, and distance to ZIP code with nearest endoscopy facility. We categorized members into three geographic regions using the ZIP code version of the Rural-Urban Commuting Areas (RUCA) taxonomy based on population density, urbanization, and daily commuting patterns; urban (50,000 or more), rural (2500–49,999), and frontier (<2500) (Rural-Urban Commuting Area Codes, 2005). Accessing primary care was defined as having any visit with a primary care procedure code in the baseline study year (2010). We identified primary care use in the baseline year to ensure that measurement of this predictor variable occurred prior to or concurrent with our outcome variable. Distance to nearest endoscopy facility was calculated by using Medicaid claims data to identify all service ZIP codes where colonoscopies were performed during the study period. For each member, we then calculated the straight-line distance in miles from the residence to the nearest endoscopy center location using ZIP code centroids, consistent with prior studies (Wheeler et al., 2014; Wheeler et al., 2012). In some cases, the nearest location was in a neighboring state.

Additional independent variables were explored in statistical analyses but excluded from the final model (see below). These included county-level characteristics derived from the AHRF data, such as a population-adjusted count of medical generalists, percentage living below the federal poverty line, percentage with less than a high school education, percentage unemployed, percentage uninsured, and percentage non-white. The count of medical generalists was dichotomized at the median; the latter five variables were categorized into quartiles, consistent with prior studies (Wheeler et al., 2014).

2.6. Statistical analysis

All analyses were conducted using R version 3.2.2. We used logistic regression to predict the likelihood of CRC testing. We stratified our analysis by insurance type (Medicaid, Commercial) because these groups are likely to be different from one another in important unmeasured ways and because in pooled analyses the magnitude and significance of factors affecting CRC testing varied significantly by beneficiary group. Our models included a county-level random effect to account for additional unmeasurable, county-specific regional differences across the state by incorporating both within- and between-county variation. We focused on the county-level analyses rather than state, ZIP code, or block group analyses, because it supported comparability to prior studies, maximized the AHRF data characterizing geographic and health care provider variation, reduced analytic challenges related to small sample sizes at the ZIP code level, and would produce the most relevant data for use by health leaders and policy makers given a tendency for resources to be allocated at the county level.

Statistical tests of our model specification revealed that the random effects approach was superior to a simple logit (i.e., minimized estimated information loss based on AIC comparison). We calculated variance inflation factors (VIFs) and correlations between independent variables to ensure model assumptions were not violated. Initial testing yielded unacceptably high VIFs as well as, in some cases, model convergence warnings; we isolated this to the high correlation between the county-level AHRF variables and the county random effect In our final model, we excluded the AHRF variables since much of their explanatory power would be captured by the random effect (although not directly estimable at the variable level). Furthermore, convergence problems were encountered due to small cell sizes for two of our categorical variables – geographic location and distance to nearest endoscopy center. Our final model combined “Rural” and “Frontier” geographies, and dichotomized distance to nearest endoscopy center into two categories – “<5 miles” and “5 or more miles” to address these issues. Sensitivity analyses utilizing our original, more detailed categorization did not yield greater predictive power, based upon likelihood ratio tests. Additionally, to ensure that screening behaviors for newly age-eligible members did not vary between members turning 50 in 2010,2011,2012 or 2013, we plotted stratified Kaplan-Meier curves of time to first screening over the 12 months following members' 50th birthday. A log-rank test indicated insufficient evidence to suggest screening patterns differ significantly between cohorts ($p = 0.55$).

Results

Characteristics for the total sample (64,711 individuals) and the 4516 Medicaid and 60,195 commercial beneficiaries are summarized in Table 1. Overall, 53.3% of the sample was female. Medicaid members were predominantly white (83.2%); 5.3% were African-American and 3.8% Hispanic Race and ethnicity data were not available for commercial members. Although 76.1% of the sample had a primary care visit in 2010, Medicaid members accessed primary care more often than their commercially insured counterparts (88.5% versus 75.2%, respectively). Most members lived in urban (70.4%) versus rural/frontier areas (29.6%). However, Medicaid covered a greater proportion of lives in rural/frontier as compared to urban settings (42.1% versus 28.7%).

Considering unadjusted results, less than half (42.2%) of the sample had any evidence of CRC testing during the four year study window Observed modalities included colonoscopy (53%), fecal testing (45%), and sigmoidoscopy (2%). CRC testing was observed in 34.9% of the Medicaid and 42.8% of the commercially insured members. As summarized in Table 2, after controlling for age, multivariable models indicated that members had higher odds of CRC testing if they were female (OR 1.04, 95% CI 1.01–1.08) and lived in an urban area (OR 1.14, 95% CI 1.07–1.21). Members insured by Medicaid had lower odds of CRC testing (OR 0.67, 95% CI 0.62–0.71) compared to commercially insured beneficiaries. Although distance to the nearest endoscopy facility was not associated with CRC testing (OR 0.98, 95% CI 0.92–1.03), access to primary care was associated with higher odds of CRC testing (OR 2.47, 95% CI 2.37–2.57). Medicaid members had 3.51 times higher odds of testing if they received primary care during the baseline year (95% CI 2.72–4.53) while commercial members with primary care engagement had 2.45 times higher odds of CRC testing (95% CI 2.35–2.55).

Fig. 2 displays average predicted probabilities of CRC testing by county based on observed rates of testing for those turning 50. Predicted CRC testing probabilities for combined Medicaid and commercial beneficiaries varied from 22.4% to 46.8% across Oregon's 36 counties. At the county level, the predicted probability for CRC testing averaged 30.4% for Medicaid members (Range: 19.4%–40.0%) and 36.0% for commercial beneficiaries (Range: 22.5%–47.2%). Only one county (<3%, 1/34) had testing rates for Medicaid beneficiaries above 40%; in contrast 12 counties had testing rates above 40% in commercially insured members (33%, 12/36).

Fig. 3 demonstrates trends in AHRF area-level socioeconomic status and physician availability by rank-ordered county average predicted probabilities of CRC testing; lighter shading of cells indicates lower levels of socioeconomic deprivation or more clinicians per capita. Although we dropped AHRF variables from the regression model because of convergence issues and the fact that much of their explanatory power was captured by use of county as a random effect, this figure suggests regional characteristics that may be associated with county-level CRC testing. In general, counties with indicators suggesting higher socioeconomic deprivation (e.g., fewer individuals who completed high school, higher unemployment rates, higher uninsurance rates) as well as a lower number of medical specialists per 1000 residents also had lower CRC testing rates.

Interestingly, several of the counties with the lowest CRC testing rates had the *highest* number of Family Medicine physicians per 1000 residents (see Fig. 3; 89% of the counties with the highest physician rate are also in the lower 50% of counties for CRC testing). However, as detailed in Fig. 4, *accessing* primary care also varied by county. In 94% of Oregon's counties (32/34; two of the 36 counties were excluded due to small sample size) >80% of Medicaid members accessed primary care in 2010. In contrast, only three counties had >80% of commercial members access primary care in 2010.

4. Discussion

CRC screening beginning at age 50 is a cost-effective public health tool to reduce CRC morbidity and mortality. However, our analysis of Medicaid and commercial claims found that, despite insurance coverage, only two out of five (42%) newly age eligible beneficiaries had any evidence of CRC testing over the four year study window. Across Oregon's 36 counties, CRC testing predicted probabilities for combined Medicaid and commercial beneficiaries varied from 22.4% to 46.8%. Counties with higher rates of socioeconomic deprivation (e.g., lower high school graduation rates, greater unemployment and uninsurance rates) and lower rates of endoscopy specialists also tended to have lower CRC testing rates. After controlling for age, patients were significantly more likely to be tested if they were female, commercially insured, or urban residents. In the regression analysis, accessing primary care, but not distance to endoscopy, was associated with CRC testing. Although Medicaid-enrolled beneficiaries were more likely than commercial members to access primary care, they were still less likely to receive CRC testing. Thus, simply having access to health insurance coverage (an individual-level factor) may not be sufficient to reduce disparities in CRC screening (Stimpson et al., 2012).

Although we detected both colonoscopy (53%) and fecal testing (45%) in the claims data, neither Medicaid nor commercially insured members received CRC testing at the rates needed to achieve current national targets (National, Colorectal Cancer Roundtable; US, Department of Health and Human Services). Our findings align with prior studies which demonstrate that CRC testing rates are suboptimal in the US and identify barriers and facilitators to screening at three levels: patient, provider, and context Male gender and rural geography are two prevalent patient-level barriers (Wheeler et al., 2014; Ojinnaka et al., 2015; Anderson et al., 2013; Holden et al., 2010). Similarly, having a usual source of care is an important predictor of CRC test use, particularly for populations experiencing disparities (Jandorf et al., 2010; Wilkins et al., 2012; Hughes et al., 2015; Benarroch-Gampel et al., 2012). Contextual factors including area poverty rates, high unemployment and high levels of uninsurance have also been found to be significantly associated with lower CRC screening after controlling for patient-level characteristics (Lian et al., 2008; Mobley et al., 2010; Pruitt et al., 2009; Schootman et al., 2006; Calo et al., 2015). This study extends this research by using AHRF and claims data to explore the influence of individual- and geographic-level factors concurrently in an insured, newly age-eligible population.

Unlike prior research, we did not find distance to endoscopy or race to be important predictors of CRC testing (Wheeler et al., 2014; Anderson et al., 2013; Liss and Baker, 2014). The lack of a race effect in the Medicaid population may be because racial disparities are less likely to be observed in settings with lower overall CRC testing (Burnett-Hartman et al., 2016). The discrepancy between our findings and prior research on endoscopy distance may relate to differences in colonoscopy test preferences, how distance to endoscopy was calculated (e.g., straight line versus actual travel time) (Wheeler et al., 2014; Anderson et al., 2013), or because factors other than distance present more pertinent barriers to screening in an insured population (Charlton et al., 2016). Under these conditions how and when healthcare providers recommend screening, social support to provide transportation to colonoscopy or to encourage fecal testing, and educational/outreach campaigns to promote screening may be more important factors. Moreover, distance itself may not be as predictive of screening uptake when we consider FIT/FOBT for CRC testing in addition to colonoscopy.

Given the relationships between CRC testing and Medicaid enrollment, rural residence, and access to primary care, interventions targeting these dimensions are likely critical. The apparent lack of association between physician density at the county level and CRC testing rates contrasted against the higher odds of screening having accessed primary care suggests that it is not simply availability, but the actual engagement with primary care that shapes CRC testing. Numerous evidence-based interventions focused on patients (e.g., reminder and recall, removing structural barriers) and providers (e.g., audit and feedback) have been shown to improve CRC screening across diverse populations (Holden et al., 2010; Sabatino et al., 2012; Brouwers et al., 2011; The Community Guide). Initiatives to improve care through implementation of primary care medical homes (PCMHs) or regional accountable care organizations (ACOs) may present opportunities to increased CRC screening rates since they help to systematize delivery of cancer screening and preventive services (Green et al., 2016). Research exploring the impact of PCMH/ACO implementation and CRC screening trajectories over time is warranted. For example, in Oregon, 16 regional Coordinated Care Organizations (CCOs) provide an environment ripe for implementing interventions to improve CRC testing for Medicaid beneficiaries. CCOs were established in 2012 to provide comprehensive care for the Medicaid population and they are similar to ACOs in that they are locally governed, accountable for triple aim objectives (i.e., access, quality, spending), and emphasize PCMHs (McConnell, 2016). CCOs also accept full financial risk for the Medicaid population; performance is assessed annually using quality metrics, which include CRC screening (Oregon Health Authority).

Efforts are also needed to implement and adapt interventions for patients in rural settings. Although many evidence-based interventions to improve CRC screening have been tested in settings serving low-income Medicaid or uninsured patients, only a handful have been conducted in rural settings (Davis et al., n.d.). Our study demonstrates that although CRC testing rates were low across the entire state, 13 counties had fewer than 30% of eligible members receive CRC screening - all of which were rural. Current guidelines to improve CRC testing encourage the use of shared decision making and activities to promote the message “the best test is the one that gets done.”(Gupta et al., 2014; Lieberman et al., 2016) Efforts to increase FIT/FOBT as a population-level modality for CRC screening may be especially critical in rural settings. For example, if rural patients are more burdened with competing demands, structural barriers to accessing care (e.g., transportation), and costs of care, then systems may need to prioritize FOBT/FIT with colonoscopy follow-up on abnormal tests. Launching FOBT/FIT kit campaigns may be particularly impactful in addressing screening disparities in rural and Medicaid populations as they help reduce structural and geographic barriers to CRC screening and have demonstrated effectiveness and cost-effectiveness in these populations (Briant et al., 2015; Charlton et al., 2014; Hillyer et al., 2011; Coronado et al., 2011; Gupta et al., 2013b).

We are also aware of several limitations. General limitations of analyses using claims data include: limited ability to assess patient-provider decision making, incomplete timeframes needed to validate some CRC testing modalities (e.g., colonoscopy) to determine up-to-date screening status, potential for under-ascertainment of low-cost tests such as FOBT, and inability to understand screening patterns in uninsured and non-continuously enrolled populations (Schenck et al., 2007; Schenck et al., 2008). However, use of claims data overcomes many of the challenges related to patient recall and social desirability bias in self-reported data (Dodou and de Winter, 2015; Bradbury et al., 2005). Second, our analysis was limited to those who turned 50 during the observation period and met stringent inclusion criteria. We made these choices because we wanted the most comprehensive data for our cohort. Finally, because of Oregon's rural nature, some counties had very small sample sizes for the population of interest; two counties had less than five eligible Medicaid beneficiaries during the observation window. The limited population size presented challenges in data convergence and made it so that we removed all AHRF variables from the final model as they had no predictive power above county as a random effect We supplemented on our primary findings with a descriptive analysis to explore which county-level factors may be associated with CRC testing.

Despite these limitations, our approach allowed us to characterize relative differences in CRC testing rates at the population-level and to identify counties where CRC testing rates are most problematic. Our focus at the county level provides actionable information that can inform state and regional stakeholders can use to inform resource allocation to increase CRC screening (Wheeler and Basch, 2017). Our study's strengths include its large sample size, inclusion of all enrolled Medicaid and a substantive majority (93%) of the commercially insured beneficiaries in the state of Oregon, and the multilevel analytic approach. In addition, our study is innovative because we measured primary care utilization from claims and found it to be an important predictor of CRC testing, particularly in the Medicaid population. Consideration of regional disparities and population specific needs may help inform intervention selection and implementation (Sheinfeld Gorin and Heck, 2005). For example, lower rates of CRC testing across Oregon's 36 counties likely contribute to differences in CRC outcomes including stage at diagnosis and CRC mortality (Mobley et al., 2012a, 2012b; Mobley et al., 2014). Such information is needed by stakeholders to point to specific geographic areas or populations within individual states where evidence-based interventions can be adapted and targeted for local implementation, an important direction for public health planning (Wheeler and Basch, 2017). Our study points to opportunities to move the needle for CRC screening in Medicaid and commercially insured populations through modifiable levers in one state by adapting CRC-focused interventions to help Medicaid, male, and rural populations overcome their unique barriers to care and engaging primary care settings more actively in CRC screening endeavors, as they are critical in influencing CRC testing for both Medicaid and commercial beneficiaries.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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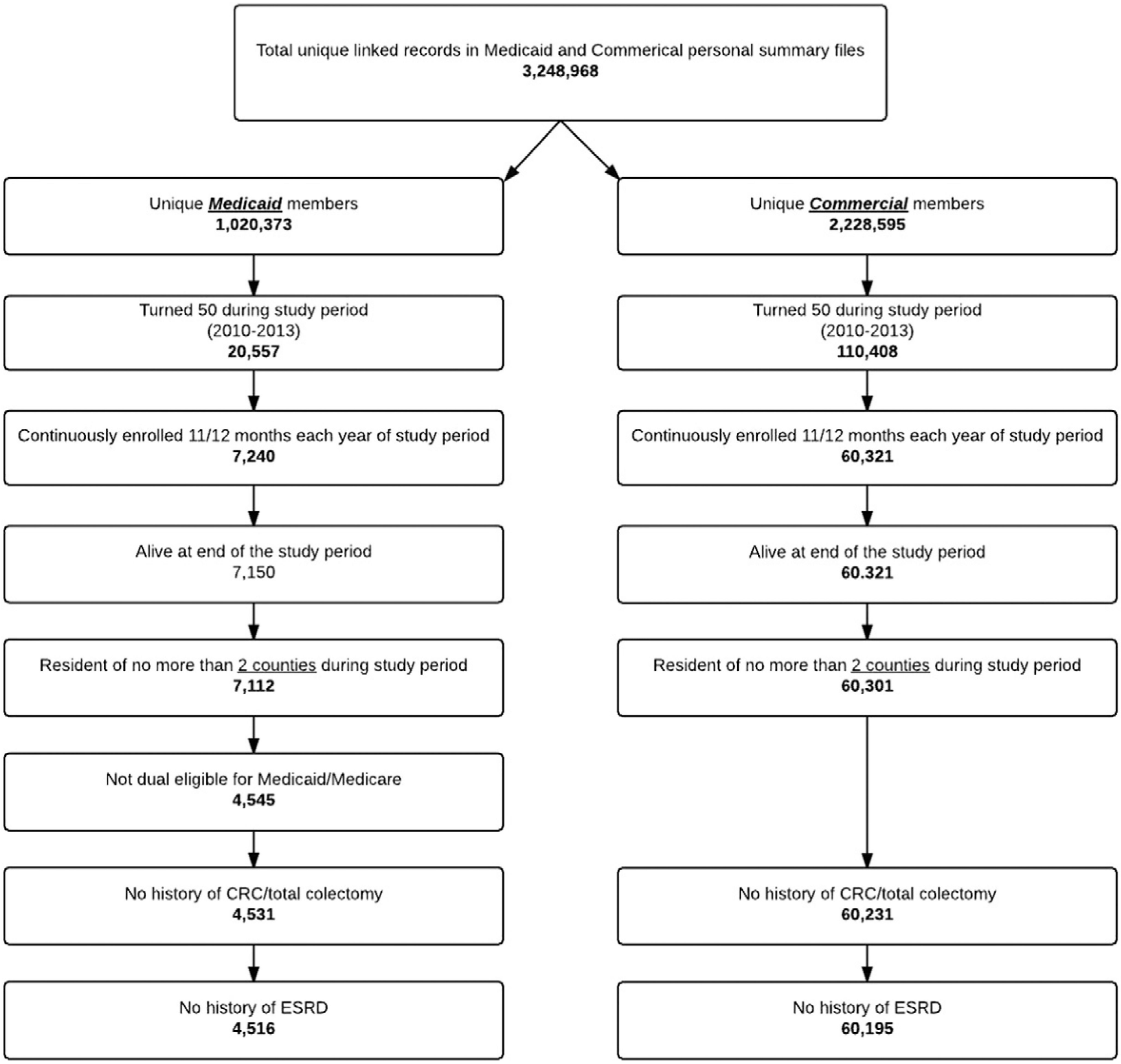

Fig. 1.

Exclusion criteria applied to generate analytic sample for Medicaid and Commercial payers (N = 64,711 total).

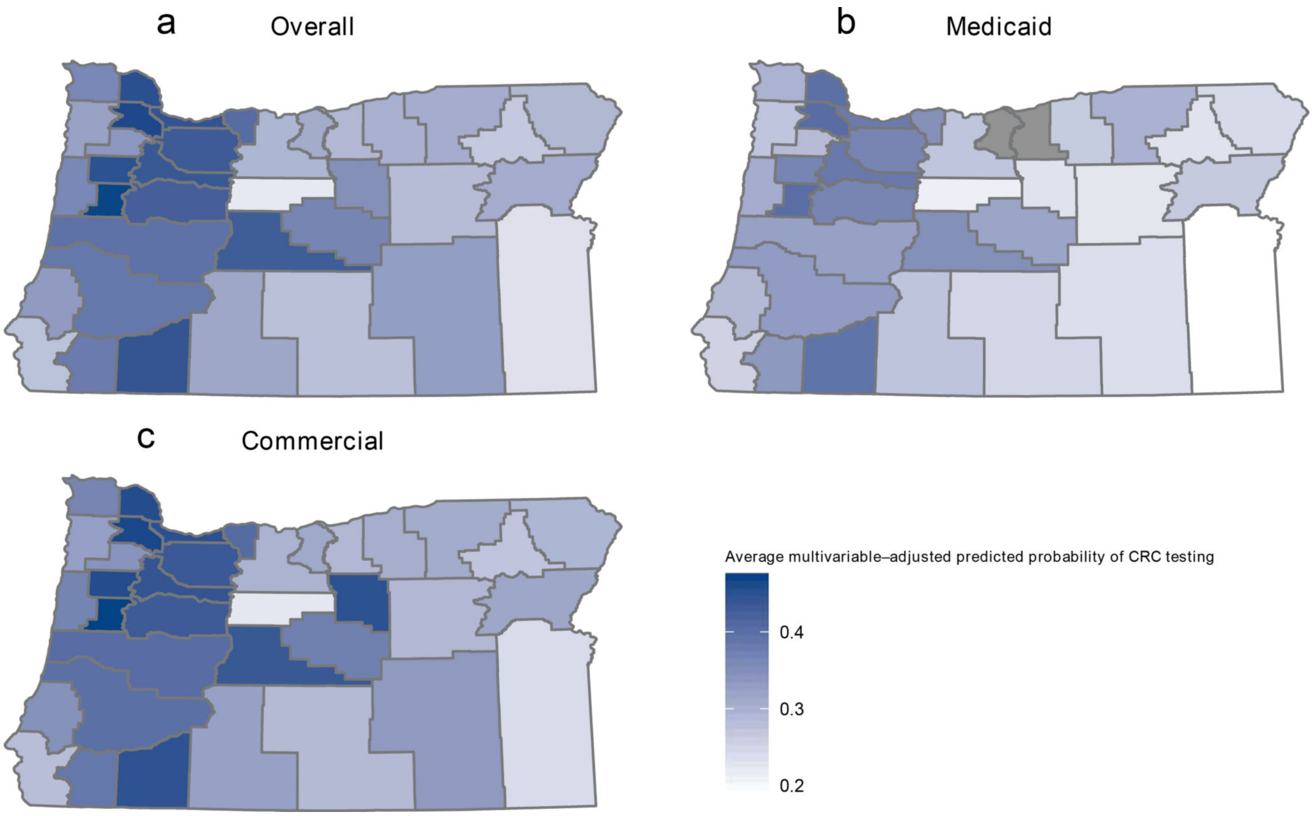

Fig. 2.

Multivariable-adjusted predicted probabilities of CRC testing by county. Notes: These maps depict multivariable-adjusted regional variation by county in colorectal cancer testing during a 4 year period among people turning 50 years of age who were insured during 2010–2013 (panel a: Medicaid and commercial; panel b: Medicaid only; panel c: commercial only). Shading reflects county-specific predicted probabilities in 10 unit increments, as generated from multivariable models. Predicted probabilities were calculated by averaging the individual predicted probabilities from the final model for each county. Increasingly darker blue shading indicates higher levels of CRC testing across the state, whereas increasingly lighter blue shading indicates lower levels of CRC testing across the state, controlling for specified person-level and county-level factors. We excluded counties with <5 members in the originally observed data; in panel b (Medicaid only) these two counties are shaded in brown.

	< HS Educ	< FPL	Unemployed	Uninsured	Fam Med MDs	Specialists
Jefferson - 22.4	16.3	21	10.7	25.1	4.1	0.9
Malheur - 23.4	20.2	25.8	8.7	22	1.3	3.3
Union - 26.6	10.7	19	8.2	17.2	1.9	7
Curry - 27.6	9.2	17.9	10.6	18.7	4.5	1.8
Lake - 27.9	13.6	19.8	11.1	20.2	5.1	0
Grant - 28.5	11.2	18.8	11.8	20.7	9.6	0
Gilliam - 28.9	10.4	11.6	6.9	15.2	0	0
Wallowa - 29.0	7.7	16.6	9.9	19.5	8.8	2.9
Wasco - 29.4	16.7	17	7.1	21.9	3.5	4.3
Morrow - 30.0	21.7	15.5	7.8	20.1	2.7	0.9
Baker - 30.5	11.9	19.3	9.2	17.4	6.9	1.9
Umatilla - 30.5	17.8	17.5	8.1	21	2	2
Sherman - 30.7	9.8	14.8	7.3	16.6	0	0
Klamath - 31.4	12.8	19.9	10.7	21.6	8.3	3.3
Tillamook - 32.1	11.5	15.4	7.2	22.7	5.5	2
Harney - 32.8	10.6	18.5	12.3	21.9	8.3	0
Coos - 33.2	12.2	20.6	9.9	18.6	3.2	6.4
Yamhill - 33.8	12.8	16.9	7.4	17.4	3.3	4.7
Wheeler - 34.9	12.8	21.8	7.1	22	0	0
Clatsop - 35.7	8.2	17.1	6.8	17.5	4	3.5
Lincoln - 35.8	10.7	18.5	8.2	21.7	2.2	2.8
Crook - 36.4	14.6	18.9	12.3	18.6	3.9	0
Josephine - 37.6	11.8	22.2	10.9	19.4	3.4	3.7
Douglas - 38.6	13.2	21.3	10.8	18.2	1.9	5
Lane - 39.3	9.4	22.1	7.6	17.7	4	7.3
Hood River - 40.2	17.7	14	6.1	21.6	13.3	7.1
Linn - 42.2	11.3	17.6	9.7	16.6	4.5	2.4
Deschutes - 42.8	7	15.8	9.5	18.2	3.9	8.3
Clackamas - 43.0	7.6	9.3	6.8	13.7	2.6	8.1
Marion - 43.3	16.9	20.2	8.4	20.6	4.2	4.7
Jackson - 43.9	10.6	18.1	9.5	19.2	4.1	8.1
Multnomah - 44.1	10.5	18.3	6.9	16.7	4.5	19.4
Polk - 44.7	10.1	16.2	7.6	15.6	2.4	2.6
Columbia - 45.0	11.1	15.8	8.2	15.2	1.4	1.4
Washington - 45.9	9.3	12.1	6.3	14.1	2.6	10.4
Benton - 46.8	6	19.7	5.8	13.7	3.8	13.2

Fig. 3.

Average multivariable-adjusted predicted probabilities of CRC testing by county, compared to county-level socioeconomic status and health care attributes. Notes: Values following county names represent predicted probability of CRC testing for combined commercial and Medicaid beneficiaries. County socioeconomic status (SES) attributes (columns) derived from 2013 to 2014 Area Health Resource File (AHRF), with actual values recorded in each cell. Cell shading represents quartiles, with lighter shading indicating desired direction (e.g., less socioeconomic deprivation, higher numbers of clinicians per population size). Labels are defined as follows: “<HS Educ” = percent of persons 25 + years with less than high school diploma. “<FPL” = percent of persons in poverty. “Unemployed” = Unemployment rate, 16+ years. “Uninsured” = percent of persons 40–64 without health insurance. “Fam Med MDs” = rate of Family Medicine MDs per 1000 residents. “Specialists” = rate of medical specialists per 1000 residents.

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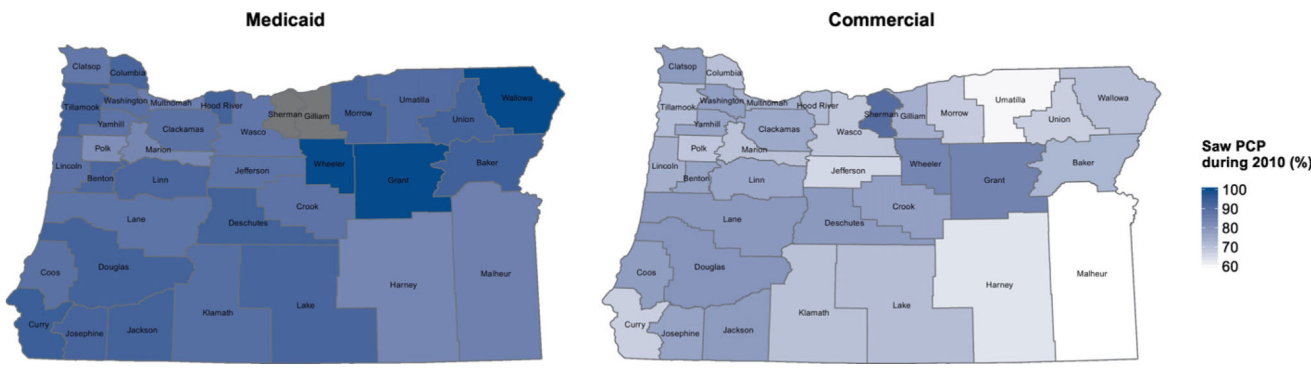

Fig. 4.

Access to primary care by eligible Medicaid and commercial members by Oregon county (i.e., use of primary care in baseline study year). Notes: This map was generated by using 2010 data from Oregon's All Payer All Claims Database to determine the percentage of eligible Medicaid and commercial beneficiaries who used primary care services by county. The percentage of eligible beneficiaries who saw any primary care provider (PCP) in each county is indicated by color, where darker shading reflects a greater percentage of visits by members and lighter shading reflects a lower percentage of visits by members at the county level. We identified primary care use in the baseline year (2010) to ensure that measurement of this predictor variable occurred prior to or concurrently with our outcome variable. Two counties (i.e., Sherman, Gilliam) had <5 eligible Medicaid members during the study period; these counties appear shaded in brown in the Medicaid map and were excluded from the current analysis.

Table 1

Sample characteristics, overall and by insurance provider (Medicaid, Commercial).

Variable	Category	Overall cohort		Medicaid only		Commercial only	
		N	**%**	**N**	**%**	**N**	**%**
Sample size		64,711	100	4516	100	60,195	100
Unadjusted CRC testing completed		27,310	42.2	1576	34.9	25,734	42.8
Gender	Female	34,503	53.3	2907	64.4	31,596	52.5
Race/ethnicity	White (non-Hispanic)	NA	NA	3758	83.2	NA	NA
	African-American (non-Hispanic)	NA	NA	239	5.3	NA	NA
	Hispanic	NA	NA	172	3.8	NA	NA
	Other/unknown	NA	NA	404	8.9	NA	NA
Observed years from age 50	1	15,450	23.9	1061	23.5	14,389	23.9
	2	16,015	24.7	1168	25.9	14,847	24.7
	3	16,476	25.5	1101	24.4	15,375	25.5
	4	16,770	25.9	1186	26.3	15,584	25.9
Access to primary care (PCP visit during 2010)	Yes	49,262	76.1	3997	88.5	45,265	75.2
	No	15,449	23.9	519	11.5	14,930	24.8
Geography	Urban	45,526	70.4	2614	57.9	42,912	71.3
	Rural/frontier	19,185	29.6	1902	42.1	17,283	28.7
Distance to nearest endoscopy facility	0–5	52,142	80.6	3463	76.7	48,679	80.9
	>5–10	5834	9.0	390	8.6	5444	9.0
	>10–15	4306	6.7	367	8.1	3939	6.5
	>15	2429	3.8	296	6.6	2133	3.5

Table 2

Multilevel multivariable logit model with random effects: odds ratios for receipt of CRC testing in total sample and stratified by insurance type.

Variable	Category	Total sample (N = 64,711)			Medicaid (N = 4516)			Commercial (N = 60,195)		
		OR	95% ci		OR	95% ci		OR	95% ci	
Insurance	Commercial-only	Ref								
	Medicaid-only	0.67	0.62	0.71	NA	NA	NA	NA	NA	NA
Race/ethnicity	White (non-Hispanic)	NA	NA	NA	Ref			NA	NA	NA
	African-American (non-Hispanic)	NA	NA	NA	1.02	0.76	1.36	NA	NA	NA
	Hispanic	NA	NA	NA	1.10	0.79	1.53	NA	NA	NA
	Other/unknown	NA	NA	NA	1.06	0.84	1.33	NA	NA	NA
Gender	Male	Ref								
	Female	1.04	1.01	1.08	1.22	1.07	1.39	1.03	1.00	1.07
Observe years from age 50	1	Ref								
	2	1.94	1.85	2.04	1.67	1.38	2.01	1.96	1.87	2.06
	3	2.77	2.64	2.91	1.90	1.57	2.29	2.84	2.70	2.99
	4	3.41	3.25	3.58	2.17	1.81	2.61	3.53	3.35	3.71
PCP visit during 2010	No	Ref								
	Yes	2.47	2.37	2.57	3.51	2.72	4.53	2.45	2.35	2.55
Geography	Rural/frontier	Ref								
	Urban	1.14	1.07	1.21	1.31	1.10	1.56	1.13	1.06	1.21
Distance to nearest endoscopy facility	<5	Ref								
	≥5	0.98	0.92	1.03	1.09	0.91	1.31	0.97	0.91	1.03

Abbreviations: NA = not available.

Notes: Model includes a county-level random effect to account for unmeasured intra-county correlation.